20

# EFFECT OF ELECTRIC FIELD ON THE NATURAL CONVECTIVE HEAT-TRANSFER TO INSULATING LIQUIDS

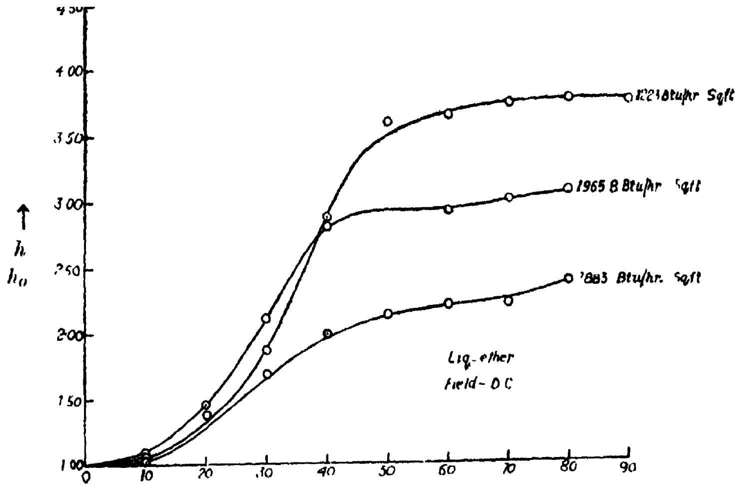
S. P. BASU AND D. B. SINHA

DEPARTMENT OF APPLIED PHYSICS, CALCUTTA UNIVERSITY

(*Received August 29, 1965*)

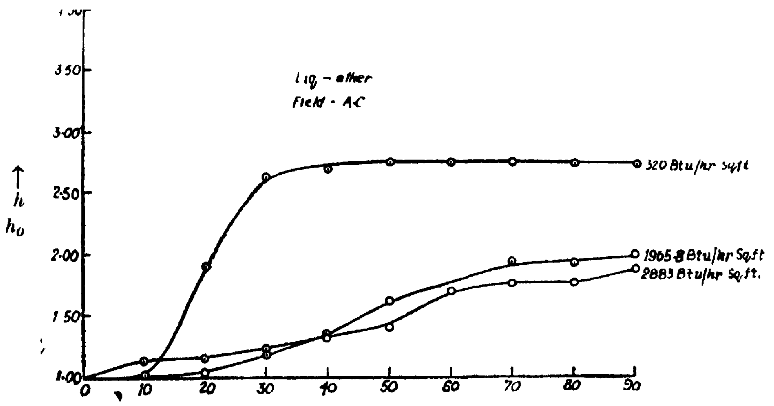
Many investigators (Allen, 1959, Watson, 1961, Care and Swan, 1963), in recent years have worked on the problem of change in the rate of heat transfer due to the application of electric fields. They investigated the effects of both d.c. and a.c. fields. In almost all cases the max. field applied at the surface of the heater was quite high, of the order of 300 kv/cm. Watson explained the increment in heat transfer observed by him as the result of forced flow from the heater surface down the gradient of permitivity caused by the temp gradient. Ostronmov in 1956, observed motion of insulation liquids under the action of electric fields in a non-convective thermal field. Ostronmov in his experiments applied quite modest fields of the order of 1 kv/cm In the present investigation, we have studied the effect of electric fields from 0-15 kv/cm. on different liquids, both a.c. and d.c. fields being used.

The apparatus consists of a heater tube surrounded by a sector shaped cylindrical electrode which runs almost over the entire length of the heater This particupar shape of the electrode was adopted so as to allow the convection currents to flow unhindered. The heater tube and also the electrodes were kept horizontal.

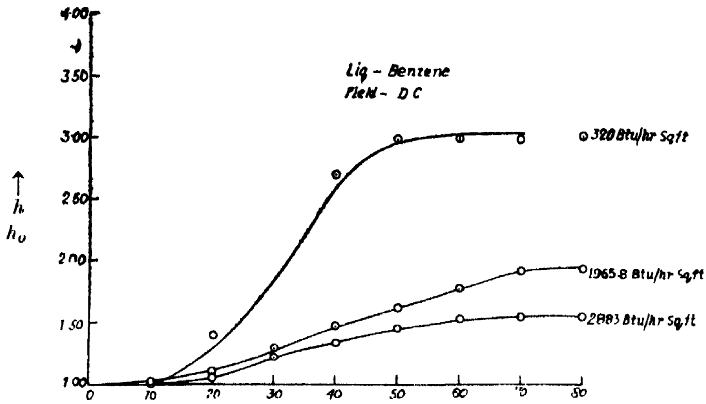



Field in K V. per cm. units →

Fig 1.




Field in K.V. per cm. units -
Fig 2




Field in K.V. per cm. units →
Fig 3

The heater tube was itself used as a resistance thermometer (Basu 1964) and was maintained at ground potential. The bulk temperature of the liquid was measured by copper-constantants thermocouples using a Disselhorst thermo-electric-free potentiometer which was also used to evaluate the surface temperature of the heater tube.

The a.c. voltages (50 c/s) used were obtained from a small transformer. The d.c. voltages were obtained from a rectifier provided with necessary filters. The ripple content was less than 0.3%. The voltages (both d.c. and a.c.) applied could be varied smothly over the entire range. Fig. 1, 2, 3, 4, depict the results for di-ethyl ether and benzene. The liquids were supplied by Messrs. B.D.H. (Pvt.) Ltd. and were labelled pure. The heater tube was of 0.476 cm. external diameter and the outer electrode of 2 cm internal diameter.

The curves were plotted with $h/h_0$ as the ordinate (where $h_0$ stands for heat transfer coefficient without the electric field and $h$, the heat transfer coefficient with the field, $h$ is here expressed in Btu/hr Sq.ft , °F.) and field in kv/cm units as the abscissae. The actual maximum field applied was 15-17 kv/cm.

For diethyl ether [Fig. 1, Fig. 4(a)] the application of d.c. field increases the rate of heat transfer but the effect gradually decreases with increasing values

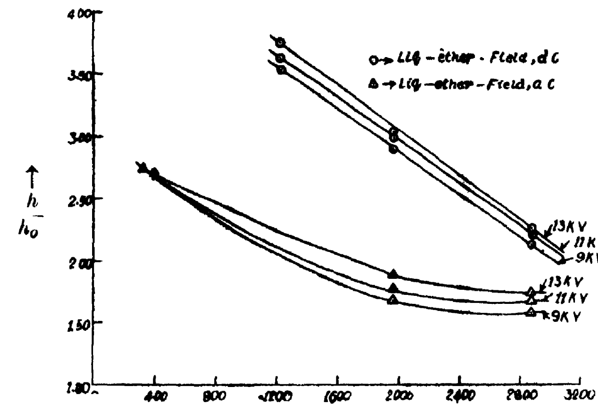



Fig 4(a) q → heat flux (q) → B t u/hr sq ft

of heat flux. For a c. fields [Fig. 2, Fig. 4(a)] also the rate of increase of heat transfer gradually decreases with heat flux.

For benzene [Fig. 3 Fig. 4(b)] with d c. field also a similar pattern as above follow.

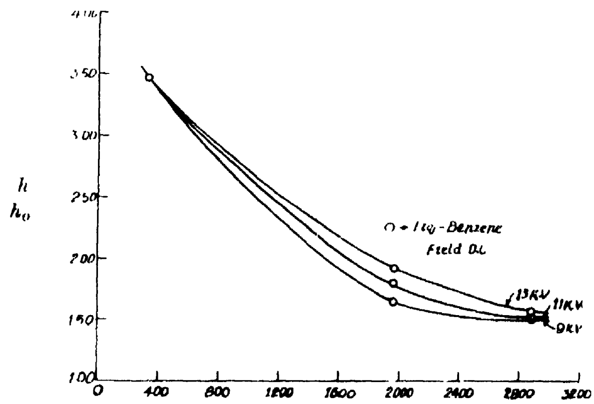



Fig 4(b) q → heat flux, B t u/hr. sq. ft.

From the present set of experiments it is clear that with the increase in the values of the heat flux the rate of heat transfer decreases. This is due to the fact that as the heat flux increases, circulation in the liquid improves and thereby the permittivity gradient resulting from the diminished temperature gradient also falls. So the heat transfer also should fall. The saturation stage for each curve is reached when the increased heat transfer due to increased circulation is inhibited by the fall of heat transfer resulting from the fall of the permittivity gradient.


REFERENCES

Allen, P. H. G., 1959, *Brit. J. of App. Phys.*, **10**, 347.

Basu, S. P., 1964, *Ind. J. Phys.*, **38**, 87.

Care, J. M. and Swan, D. W., 1963, *Brit. J. of App. Phys.*, **14**, 263.

Ostroumov, G. A., 1956, *Soviet Phys., J.E.T.P.*, **3**, No. 2.

Watson, P. K., 1961, *Nature, Lond.*, **189**, 563.